A NEW RABBIT CESTODE, CITTOTÆNIA MOSAICA.

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The adult tape worms of rabbits have been of considerable importance in the history of helminthology, not only from their anatomical peculiarities, but from their relation in structure and, probably, life history to allied parasites in the horse, cow, and sheep, and from their part in the revision of the old cestode genera.

The Old World genera of rabbit cestodes, *Andrya*, *Anoplocephala*, and *Cittotænia* are all Anoplocephalinæ and hence unarmed. The American genera *Bertiella* and *Cittotænia* are likewise Anoplocephalinæ, while the genus *Davainea* belongs to the Dipylidiinæ and is armed.

Cittotænia is the only genus of rabbit cestodes represented both in the Old World and in America. To this genus the new species described in this paper is added.

The author is indebted to Dr. Rufus A. Lyman and Dr. Henry B. Ward of the University of Nebraska for the use of Lyman's slides of *C. pectinata*, and to Dr. B. H. Ransom, Chief of the Division of Zoology, U. S. Bureau of Animal Industry, for assistance in the preparation of this paper. The illustrations were made by Mr. W. S. D. Haines, artist of the Bureau of Animal Industry, and are from camera drawings unless otherwise stated.

CITTOTÆNIA MOSAICA, new species.

Five specimens of *Cittotænia mosaica*, new species, were collected by the writer from the small intestines of a large "mountain cottontail rabbit" shot July 12, 1906, on the road from Rosemont, Colorado, to the Seven Lakes in the Pikes Peak region of the same State. From the locality and altitude, the latter over 11,000 feet (3,353 meters), the host was undoubtedly *Lepus pinetis* (=*Sylvilagus pinetis*), the form listed for this locality and for high altitudes by Warren (1906). In a personal communication, Mr. Warren writes me "I

have no hesitation in saying that a cottontail taken at the locality you mention would be *Lepus pinetis*." In a later paper, Warren (1908) lists this host as *Sylvilagus pinetis*.

I have found only two references to rabbit cestodes from Colorado.

One is an article by Curtice (1892), in which he writes: "In Colorado, cottontail rabbits (*Lepus sylvaticus* Bachman) yielded in 1886 an undescribed Taenia." I have not been able to locate these specimens.

In looking over the files of a sheep breeder's periodical I find a note by a contributor signed "D. K." (1900), who writes from some unspecified locality in Colorado as follows: "Nearly every rabbit here has tapeworms in it."

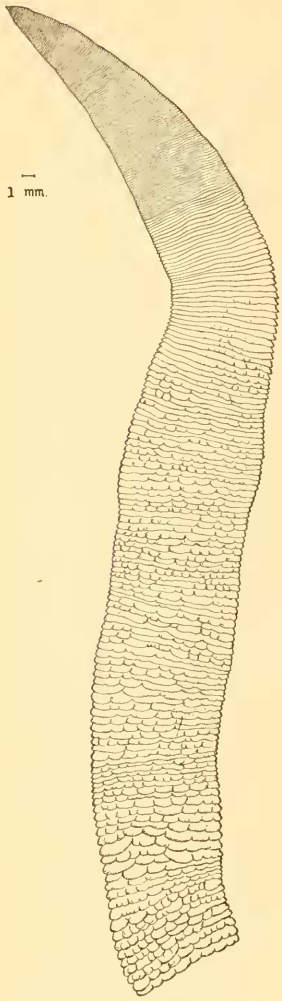

FIG. 1.—VIEW OF ENTIRE ANIMAL, SHOWING MOSAIC MARKING.

The specimens of *C. mosaica* were much folded in the intestine, but were readily straightened out after fixation. The lengths of the cestodes were as follows: 5.3 cm., 7.5 cm., 7.5 cm., 8.7 cm., and 10 cm. The proglottids are much broader than long, the maximum breadth being 8 to 10 mm., the maximum length of end proglottids 1 mm., and the maximum thickness 2 mm. Viewed from the dorsal or ventral surface toward the head and especially in the posterior part of the strobila, the separate proglottids show several irregularities, constrictions, and depressions across their breadth, giving the broad surfaces somewhat the appearance of a mosaic, whence the specific name. (Fig. 1.)

The unarmed head is dome-shaped and is actually and relatively small. (Fig. 2.) It measures 270 to 350 μ in breadth at the base and 110 to 240 μ from the base to the tip, according to the state of contraction. The four small suckers are set far anterior and measure at the aperture 20 to 44 μ. There is no neck, segmentation beginning directly behind the head. The strobila broadens rapidly and becomes lanceolate in outline.

FIG. 2.—VIEW OF HEAD. *s*, SUCKERS.

A study of the internal anatomy readily establishes the specific distinctness of this form, and I have adapted the following key from

Stiles (1896) to show its relation to the other rabbit cestodes of the Pectinata group:

1. Anoplocephalinæ having ova with pyriform body, genital canals passing dorsal of longitudinal canals and main nerve trunk, uterus a transverse tube, single or double, genital pores double, vagina ventral of cirrus pouch on both sides_____*Cittotænia*. 2
2. Cirrus pouch muscular, generally pyriform, distinct, and swollen proximally by vesicula seminalis _____Marmotæ Group.
   Cirrus pouch resembling nozzle of hose, of nearly equal diameter throughout; not swollen by any prominent vesicula seminalis_____Pectinata Group. 3
3. Testes in a band extending across the proglottid and lateral of ovaries_____4
   Testes in groups or in a band not extending lateral of ovaries_____5
4. Cirrus pouch about 1 mm. long, extending some distance median of longitudinal canals_____*Cittotænia pectinata*.
   Cirrus pouch 475–640 μ long, entirely lateral of longitudinal canals. *Cittotænia mosaica*.
5. Testes in two groups, one for each ovary, extending lateral of ovaries but absent from median field_____*Cittotænia perplexa*.
   Testes in a band not extending lateral of ovaries_____*Cittotænia variabilis*.

C. bursaria v. Linstow (1906) may be placed with the Marmotæ group on the pyriform shape of the cirrus pouch as figured, though no vesicula seminalis is described or figured as occurring within the cirrus pouch. Other features would relate it to the Pectinata group, but for various reasons I have not discussed it further in this paper.

The anlagen of the female glands and the testes of *C. mosaica* appear almost simultaneously in about the twenty-seventh proglottid, 2 mm. from the anterior end, the genital canals first showing in the fifth or sixth segment after this. In this regard *C. mosaica* differs from the other members of this group in which the anlagen appear as follows: In *C. pectinata* the female glands and ducts are first indicated "immediately back of the head," according to Stiles (1896), the testes first appearing 6 to 7 mm. from the anterior end, Stiles (1896), Lyman (1902); in *C. perplexa* the anlagen of female glands and ducts occur 0.64 mm. from the anterior end, Stiles (1896); in *C. variabilis* roundish anlagen of the female glands, later becoming pistol-shaped, appear 5 to 10 mm. from the anterior end, Stiles (1896). Seeming differences in actual and relative occurrence of anlagen may be due to differences in technique. In *C. mosaica* the anlagen of the ovaries and testes first occur practically simultaneously in section, though the anlagen of the ovaries are visible long before those of the testes in toto mounts of the entire animal. Part of the statements of Stiles and of Lyman may have been, and in fact appear to have been, based on studies of toto mounts.

The testes are in the posterior part of the proglottid, and from a dorsal or ventral view show mostly a single row, with only occasional doubling, extending past the ovaries almost to the lateral canals. In a cross section of the worm the testes are seen to be arranged in

two or three irregular, vertical rows, so that the number of testes which from a dorsal view appears to be between 36 and 40, is found in cross section to be about 60 to 80 to each proglottid. *C. pectinata* has 100 to 125, *C. variabilis* 60 to 100. The testes are approximately globular to oval in shape, ranging in diameter from 60 to 90 μ. Each testis consists of a number of lobules which resemble in section a cluster of grapes, the whole inclosed in a capsule which defines the testis sharply from the neighboring parenchyma.

On each side of the proglottid the vas deferens is formed by the union of two tubules, one of which originates near the middle of the proglottid and the other near the margin. These unite just behind the median lobe of the ovary to form the vas deferens. Each testis connects with the tubule by a short duct. (Fig. 3.)

The vas deferens forms a series of vertical loops, extending just median of the longitudinal excretory canals for a space of 405 to 550 μ, then runs straight across these canals to the beginning of the

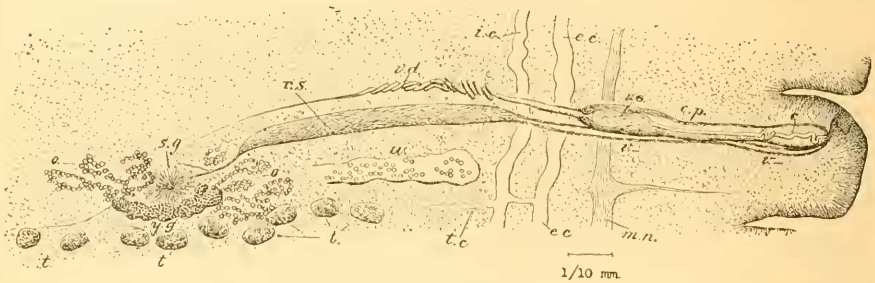

FIG. 3.—FRONTAL SECTION NEAR MARGIN OF SEGMENT. *c*, CIRRUS; *cp*, CIRRUS POUCH; *ec*, EXTERNAL EXCRETORY CANAL; *ic*, INTERNAL EXCRETORY CANAL; *mn*, MAIN NERVE; *o*, OVARY; *rs*, RECEPTACULUM SEMINIS; *sg*, SHELL GLAND; *t*, TESTES; *tc*, TRANSVERSE EXCRETORY CANAL; *u*, UTERUS; *v*, VAGINA; *vd*, VAS DEFERENS; *vs*, VESICULA SEMINALIS; *yg*, YOLK GLAND.

cirrus pouch. (Figs. 3 and 4.) This latter measures 475 to 640 μ in length, averaging 550 μ, and is wholly lateral of the longitudinal canals. In *C. pectinata* the cirrus pouch is 925 to 1,075 μ long and extends median of the excretory canals. In *C. perplexa* it is only 288 to 320 μ long, and in *C. variabilis* 400 μ. At its proximal end the cirrus pouch is 62 μ in diameter, thinning toward the distal end to 38 μ and then slightly increasing in size again. Inside the cirrus at its proximal end is a vesicula seminalis the length of which varies greatly, depending possibly on variations in the pressure of the cirrus pouch muscles. The extremes noted for its length are 129 and 337 μ.

The outer layer of longitudinal muscles of the cirrus pouch is about 3 μ thick, the inner circular layer about 5 μ thick, the cirrus about 6 μ. The cirrus pouch proceeds anterior and dorsal of the vagina nearly to the genital pit where they both open in the same frontal plane, often bending sharply forward near the end. The genital aperture is located in the anterior half of the proglottid margin, in

which respect this form differs from the diagnosis or figures of the other species of the group, in which it is given or figured as median or in *C. pectinata* as posterior also. However, in Stiles's specimens of *C. perplexa*, which I examined, I find the location to be anterior as well as median, and indeed it is so figured, though the diagnosis (Stiles, 1896) only gives the median location. In *C. mosaica* the cirrus pouch runs straight practically to the tip, or else curves slightly forward, whereas in the available European specimens of *C. pectinata*, including Riehm's cotype and those in the collection of Stiles, the cirrus pouch very commonly presents a wide arch, bowing back to the posterior part of the segment margin. This is not so noticeable in the American specimens of this species from Lyman's collection.

The anlagen of the ovaries quite generally appear bilobed in frontal section and mature ovaries very often appear so in section, though there are branches running anteriorly also. The central

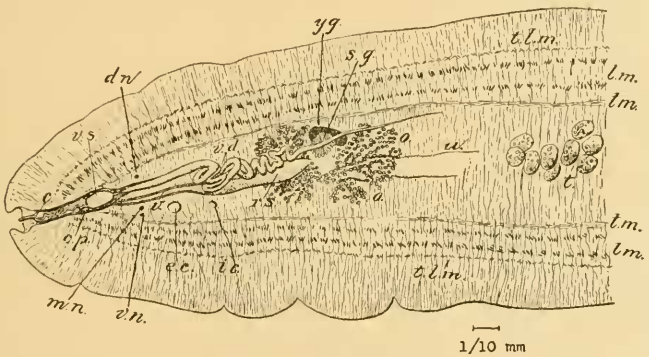

FIG. 4.—CROSS SECTION NEAR MARGIN OF SEGMENT. *c*, CIRRUS; *cp*, CIRRUS POUCH; *dn*, DORSAL NERVE; *cc*, EXTERNAL EXCRETORY CANAL; *ic*, INTERNAL EXCRETORY CANAL; *lm*, LONGITUDINAL MUSCLES; *mn*, MAIN NERVE; *o*, OVARY; *rs*, RECEPTACULUM SEMINIS; *sg*, SHELL GLAND; *t*, TESTES; *tlm*, TANGENTIAL LONGITUDINAL MUSCLES; *tm*, TRANSVERSE MUSCLES; *u*, UTERUS; *v*, VAGINA; *vd*, VAS DEFERENS; *vn*, VENTRAL NERVE; *vs*, VESICULA SEMINALIS; *yg*, YOLK GLAND.

portion of the ovary is not located anterior of the lobes of the ovary as Lyman has described and figured for *C. pectinata*, but is located ventrally, its relation to the lobes being shown in cross-section and not in frontal section. Instead of "Indian-club shaped" lobes with a maximum diameter of 16 μ at their tips, as Lyman (1902) describes for his specimens of *C. pectinata*, *C. mosaica* has a more irregular set of lobes with diameters ranging from 40 to 75 μ.

The vitellarium is a densely staining, kidney-shaped gland posterior and dorsal of the median part of the ovary and between the posterior parts of the ovarian lobes. The shell gland is a globular structure lying between the vitellarium and the median region of the ovary, and is composed of elongate cells. Measuring across the proglottid, the lateral dimensions of the various female glands are as follows: Width of ovary, 590 to 645 μ; of yolk-gland, 200 to 230 μ; of shell gland, 74 to 92 μ.

The total length of the vagina and receptaculum seminis varies with the age of the segments, increasing from 885 to 1,290 μ. At the genital depression the vagina and cirrus reach the exterior by a short tube. The vagina extends inward as a thick-walled, relatively narrow tube surrounded by deeply staining cells until it crosses the longitudinal canals when it dilates to form a thin-walled, cylindrical receptaculum seminis extending to near the median part of the ovary. Here it narrows and bifurcates, one branch proceeding to the ovary as the oviduct and one passing through the shell gland to the yolk gland. From this latter branch the ootype originates near the middle of the shell gland and proceeds to the uterus, which at first lies dorsal of the median part of the ovary in this neighborhood. (Fig. 5.)

Eggs appear *in utero* in about the seventy-second proglottid, 5.8 mm. back of the first appearance of the genital anlagen and therefore 7.8 mm. from the anterior end of the worm. This is much earlier than their appearance in *C. pectinata*, in which Stiles (1896)

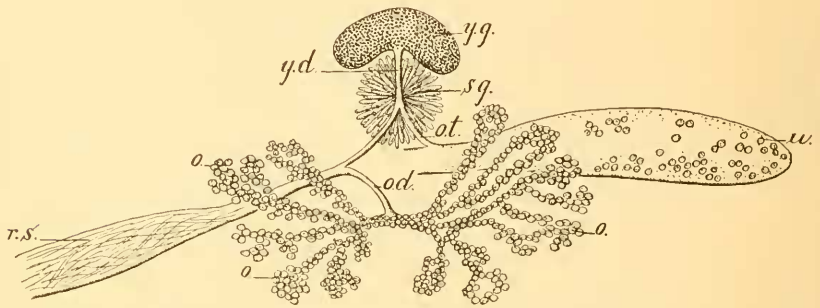

FIG. 5.—DIAGRAMMATIC VIEW, SHOWING RELATION OF FEMALE GLANDS AND DUCTS IN CROSS SECTION; *o*, OVARY; *od*, OVIDUCT; *ot*, OOTYPE; *rs*, RECEPTACULUM SEMINIS; *sg*, SHELL GLAND; *u*, UTERUS; *yd*, YOLK DUCT; *yg*, YOLK GLAND.

states that the first trace of the uterus occurs 14 mm. from the anterior end. Here, again, Stiles may have based his statement on a study of a toto preparation. Such a preparation of *C. mosaica* shows the uterus with eggs about 14 mm. from the anterior end. (Fig. 6.)

The single transverse uterus is located anterior of the yolk and shell glands and the testes. It does not extend past the longitudinal excretory canals. Lyman (1902) states that the uterus in *C. pectinata* extends past these canals, but I was unable to confirm this from his specimens and it is not so figured for the European form by Stiles (1896). As in other species of this genus, the uterus of *C. mosaica* develops pouch-like widenings along its entire extent, the pouches ultimately becoming so wide that the parts between them appear as mere digitations extending into the lumen of the uterus. These pouches are relatively wider and shallower than in *C. pectinata*, giving the uterus a more regular, more nearly cylindrical lumen.

The eggs vary in shape from spherical to the many-sided forms figured by Blanchard (1891, fig. 29) for *Moniezia pectinata* (=*Cittotænia pectinata*). The outer shell membrane is about 2 μ thick. The dimensions of the eggs are naturally very variable, ranging from 67 to 105 μ. The diameter of the pyriform bulb is about 20 μ, the length to the point at which the horns come off is 28 to 34 μ. The horns are filamentous and about 43 μ long, with a width of 6 μ at the base.

In toto preparations the ovaries are seen to disappear very suddenly with the growth of the gravid uterus (fig. 6), but the testes and a remnant of the yolk and shell gland continue for a long time, and the cirrus pouch and vagina persist to the end of the strobila.

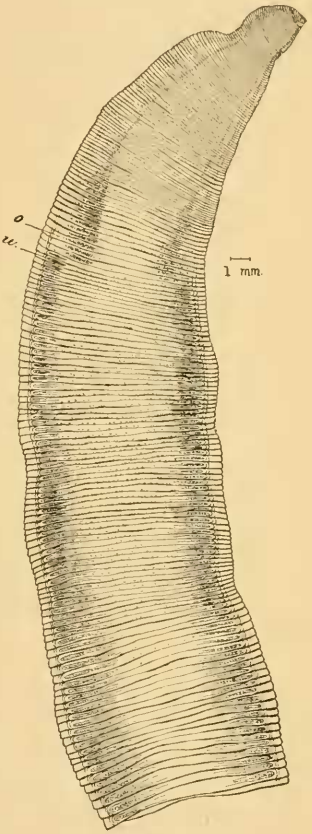

FIG. 6.—PREPARATION SHOWING ABRUPT DISAPPEARANCE OF OVARIES AND APPEARANCE OF GRAVID UTERUS. *o*, OVARY; *u*, UTERUS.

The two lateral excretory canals lie at practically the same level in the proglottid, as Stiles (1896) figures them for *C. marmotæ* (figs. 3 and 4). In *C. variabilis* the dorsal canal lies dorso-median of the ventral. Lyman (1902) gives the same position for the canals in his American *C. pectinata*, while in the European form Stiles (1896) states that a dorsal canal was not observed, and Riehm (1881) only found it for a short distance back from the head. In *C. mosaica* the external of the two canals is the larger. The transverse canals occupy the posterior part of the proglottid and connect the four canals with each other. Other smaller canals connect the main longitudinal canals of each side, while others connect the transverse canals so that the excretory system forms a network as in *C. pectinata*, underlying the dorsally situated reproductive system. In the posterior part of the strobila the transverse network disappears, as does the inner longitudinal vessel, leaving only the outer which follows closely the lateral contour of the uteri in a series of arcs. An excretory reservoir with lateral openings, as Lyman (1902) describes and figures for the terminal proglottid of *C. pectinata* was not found in *C. mosaica*, the two large external canals apparently opening in the posterior proglottid direct. Possibly the original terminal proglottid was not present in the specimens studied.

The main nerve cord lies in the same frontal plane as the excretory canals, as is also the case in *C. marmotæ*. From a plexus in the posterior part of each proglottid a conspicuous branch passes toward the margin of the segment, a smaller branch passing inward. Above and below the main cord are a dorsal and ventral cord, respectively, the former being also dorsal of the genital canals. In the posterior part of each proglottid, commissures connect the three nerve cords on each side, as stated for *C. pectinata* by Lyman (1902).

The longitudinal muscles run in two general series made up of separate bundles. These muscle sheets lie external of the reproductive, excretory, and nervous systems. The inner bundle extends just past the proximal end of the cirrus pouch, the outer continuing nearly to the margin of the segment. The same appears to be true of Lyman's specimens of *C. pectinata*, though he states that the two muscle sheets finally meet near the lateral margins. Inside of the inner longitudinal plate, the transverse muscles form a sheet of varying thickness. Here again I am unable to confirm Lyman's statement that there are two such sheets in *C. pectinata*, his specimens presenting the same appearance in this respect as those of *C. mosaica*. Where the inner sheet of longitudinal muscles recurves the transverse sheet passes on through them to the outer layer. External to the outer longitudinal sheet is a set of fine muscle fibers, running in a general antero-posterior direction but tangential to the longitudinal fibers (fig. 4). Narrow sagittal fibers traverse the proglottid dorsoventrally.

Types of this species have been deposited in the U. S. National Museum, Helminthological Collection, No. 7147 (type) and 7148 (paratype).

A hasty comparison of specimens of the European and American *C. pectinata* shows certain differences that should be determined as accidental or shown to be of specific or subspecific importance, and the writer hopes to publish a note on this in the near future as soon as additional material can be obtained.

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